EQUIPMENT DEVELOPMENT & TEST REPORT 2300-11

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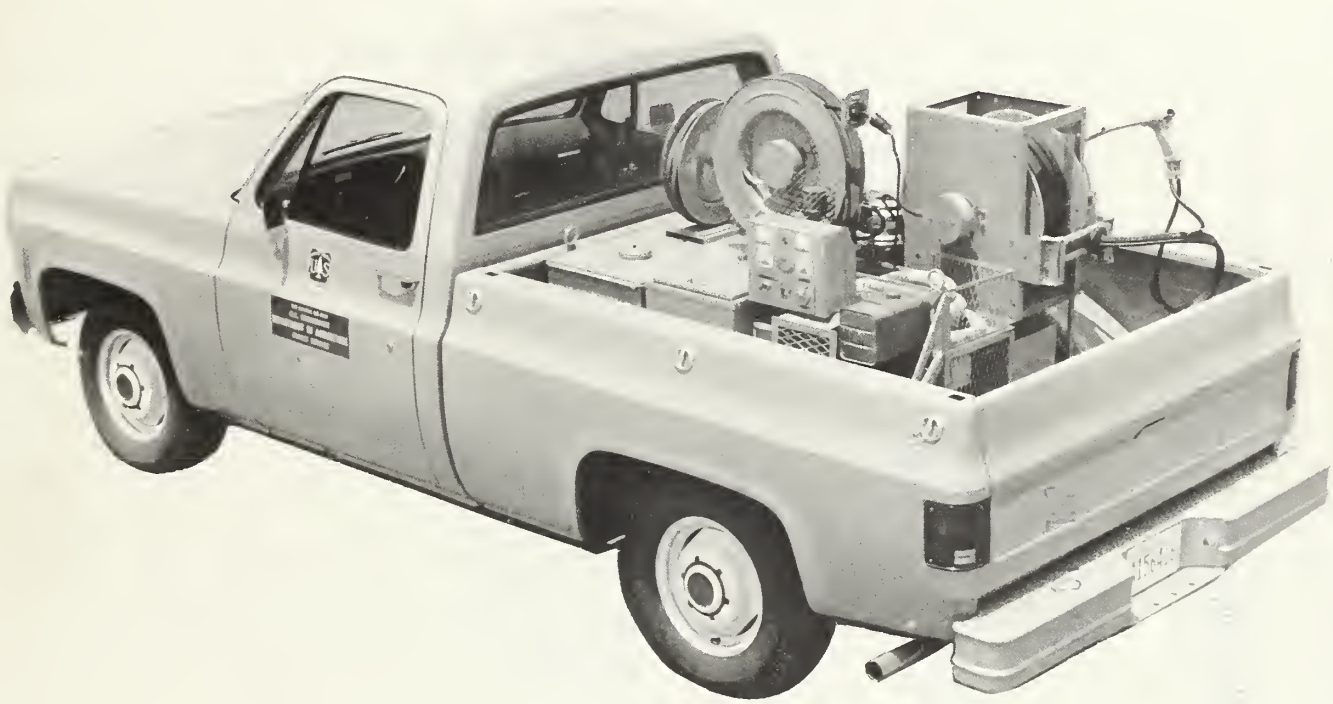

U.S. DEPARTMENT of AGRICULTURE • FOREST SERVICE
EQUIPMENT DEVELOPMENT CENTER SAN DIMAS, CALIFORNIA

Equipment Development and Test Report 2300-11

PICKUP TRUCK SLIP-ON EQUIPMENT FOR CLEANING RECREATION FACILITIES

by

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CONTENTS

ABSTRACT

After cleaning equipment for mounting on a small, narrow-track, three-wheeled vehicle was developed, attention was given to developing a similar cleaning equipment package that could slip onto the bed of a pickup truck. A prototype slip-on package was assembled, field tested, and then reconfigured into a final design. Tests show that the equipment is effective in cleaning such facilities as comfort stations, tables, and stoves at dispersed Forest Service recreation sites. The equipment can improve the quality and reduce the manhour expenditure of facilities cleaning, as well as make the work more acceptable to cleaning crews.

The private firm that had, under contract, manufactured and delivered the cleaning equipment units mounted on the small vehicle, was interested in our development of the slip-on equipment for pickup trucks. They assembled their own slip-on package similar to the San Dimas Equipment Development Center (SDEDC) design. Comparison tests that SDEDC conducted indicate that purchase of this commercially available package provides essentially the same slip-on cleaning equipment SDEDC developed and found satisfactory for servicing dispersed recreation sites at relatively remote locations.

A report on ED&T Project No. 2153—Pressure-washer Wet-vacuum Cleaning Equipment Slip-on Unit for Pickup Trucks—Sponsored by the Division of Recreation.

INTRODUCTION

Until the last 10 to 15 years, facilities such as comfort stations, tables, stoves, and fireplaces in small, dispersed recreation sites were used only moderately by the public. The facilities could be cleaned easily and economically by the use of mops and buckets, scrub brushes, and brooms. Today, recreation facilities are being used more and more by the public. Advances in the standard of living prompt the public to be more discerning, to expect a higher standard of cleanliness. Part of this expectation is that a better cleaning job be done in Forest Service facilities. But, it is increasingly difficult to hire and retain personnel who will clean recreation site facilities by manual methods.

Commercial janitorial services are now using specialized cleaning equipment and supplies. Some of these products and techniques can be applied to cleaning recreation site facilities. Mechanization and better methods can (1) lower costs by reducing manpower requirements (frequently the greatest expense in doing the job), (2) improve the quality and quantity of work, and (3) make the job more acceptable to employees.

Since 1968, the San Dimas Equipment Development Center has been working on projects to develop equipment to assist in the task of cleaning recreation facilities. In 1970, the development of a "Recreation Facilities Cleanup Vehicle" was completed (1, 2). This narrow-track, three-wheeled vehicle has a high-pressure washer as used in coin-operated car washes and a wet-pickup vacuum cleaner as used by many janitorial services. The small vehicle and the cleanup equipment it carried were intended for cleaning recreation facilities at large campgrounds or large complexes of sites that were relatively close together and accessible by no worse than secondary highways or forest roads. It could maneuver around traffic control barriers to get right next to the facility to be cleaned.

In a follow-up effort, the investigation expanded and a pickup truck slip-on package of cleaning equipment was developed. This approach provides for use of a more powerful, rugged vehicle which does not have to be used only for the cleaning of recreation facilities. Now small, dispersed recreation sites at more remote locations can be effectively and economically serviced. This development task had to take into consideration that a pickup truck cannot approach as close to a facility as a smaller narrow-track vehicle and no power take-off (PTO) unit would be available as a power source. Also important was that the cost or weight of the cleaning equipment package would not increase significantly in comparison to the equipment developed for the small cleanup vehicle.

PROTOTYPE DEVELOPMENT

Using the design already developed for the small three-wheeled vehicle as a basis, consideration was then given to the problems of extending the length of the cleaner's vacuum line from 20 to 50 ft, providing power without an available PTO unit, and keeping to a reasonable minimum both the cost and weight of the cleaning equipment for the slip-on package. The following cleaning equipment items were deemed essential to making up the package:

- High-pressure washer capable of 500 psi at the spray-gun nozzle, with all pump controls at the "gun" handle;
- Tanks for storing 15 gal of detergent solution and 30 gal of rinse water;
- Minimum of 50 ft combination high-pressure hose and low-power control cable on a spring-rewind reel;
- Wet-vacuum cleaner with a hose at least 50 ft long;
- 110-V power supply to provide adequate power for all the cleaning equipment and for portable power tools.

All of the above had to be capable of operating at an elevation of 10,000 ft and a temperature of 80°F.

Wet-vacuum Cleaner

From our work with the cleaning equipment for the small vehicle, we knew the wet-vacuum cleaner would have to be capable of moving a minimum of 50 cfm of air. As a first step, several large, stationary cleaners for possible mounting on the slip-on package were investigated. Both pneumatically and electrically powered devices were studied. All were capable of moving at least 50 cfm through a minimum hose length of 50 ft. But these units appeared prohibitively heavy and expensive. So we dropped the idea of using a cleaner that would remain on the pickup truck, and instead sought small, portable systems that could be carried from the truck. Again, both pneumatic and electric devices capable of moving 50 cfm (but, this time, only through 10 ft of hose) were investigated. It was determined that pneumatic devices in this class of cleaners were still too heavy and expensive for our requirement.

However, the small, electrically powered devices looked promising. SDEDC obtained several of these and tested them. Their performances were found to be very similar, but there were differences between them in noise level, rain resistance, tank size, power requirement, price, and minor design features. A comparison study resulted in the selection of two of these devices as candidates for evaluation on the prototype slip-on package; one designed to be carried on the back, the other by hand.

Power Supply

To provide power for both the cleaning equipment, plus any portable power tools that one may wish to operate while servicing the recreation facilities, various power supply schemes were studied. First, we looked at devices to convert the pickup truck's 12-V battery/alternator system into about 1,500 volt-amperes (watts) continuous at 110-V ac. While such devices are promoted and offered for sale at various retail outlets, the maximum rated power available from any standard pickup truck alternator was found to be 975 W and thus no device could provide the required ac power from the truck's battery on a continuous basis without draining the battery.

Next we studied PTO-driven alternators and generators, but all of these were found to require extensive modification of the pickup truck and thus were incompatible with out slip-on concept for a standard fleet vehicle.

As a third approach, SDEDC studied portable engine-driven alternators. Available engine/alternator combinations are matched for standard conditions (sea level and 60°F). The unit that would produce the required electric power at an altitude of 10,000 ft and a temperature of 80°F would have to have an alternator 40 percent larger than offered in available engine/alternator combinations. We did not feel we could afford to waste the extra weight and cost that this would entail.

Finally, we settled on an approach that would provide the power that we needed within the confines of our established ground rules. This approach consisted of using a 14-hp gas-driven auxiliary engine that would belt-drive a small 2,500-W alternator to power the portable wet-vacuum cleaner and power tools, and also belt-drive the pump for the high-pressure washer. However, since this pump could not be directly belt-driven without expensive accessory equipment, an electric clutch was installed on the pump shaft to accommodate the belt drive.

Prototype Configuration

The prototype slip-on unit that was put together (fig. 1) consisted then, of the following equipment:

- High-pressure washer made up of
  - 500-psi, 2 gpm Hypro model C5320 pump, and
  - pump support equipment, such as solenoid valves, plumbing, and strainers;
- Rectangular tank of corrosion-resistant stainless steel, compartmented to contain 15 gal of detergent solution and 30 gal of rinse water;
- Spring-retractable Coxwells Inc. reel containing 75-ft combination high-pressure hose and five-conductor, low-power control cable; selection of tips for hose nozzle;
- A Survivair-Salvage Master backpack wet-vacuum cleaner and an American Cleaning Equipment Corp. model No. 386101 hand-carry wet-vacuum cleaner;
- Power supply components
  - 14-hp Wisconsin Motor Corp. model S14D gasoline engine,

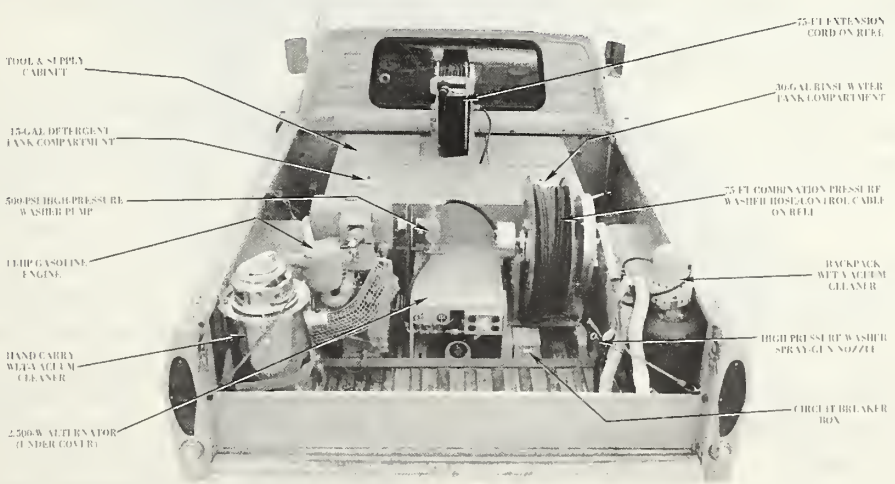

Figure 1. Prototype of slip-on equipment for cleaning recreation facilities.

- 2,500-W Pioneer Gen-E-Motor Corp. Pincor model GBRF 2500 H revolving-field alternator,

- 75-ft, heavy-duty electrical extension cord, wound on a reel, to supply power to the wet-vacuum cleaner or any portable power tools;

- Tool and supply cabinet.

The 14-hp gasoline engine belt-drives the 2,500-W alternator directly, and the 500-psi pump indirectly through an electric clutch which is activated by a wash/rinse/off switch on the spray-gun nozzle.

TEST PROGRAM

The prototype slip-on cleaning equipment package underwent a total of over 5 months of formal and comparative testing. For the first few days, shakedown tests were conducted on the San Bernardino National Forest, California Region, towards the beginning of the 1971 summer season. A few minor problems (such as the electrical extension cord coming in contact with the auxiliary gasoline engine exhaust) were discovered and corrected so that formal, structural tests would begin.

These formal tests consisted of documented operational trial use for 1-month periods at the following selected recreation sites:

- Oak Creek Canyon on the Coconino National Forest in the Southwestern Region;

- The North Fork/Trappers Lake area on the White River National Forest in the Rocky Mountain Region;

- The Georgetown Lake area on the Deer Lodge National Forest in the Northern Region;

- The Bishop Creek area on the Inyo National Forest in the California Region.

These sites provided an excellent assortment of recreation facilities and range of testing conditions. Most had comfort stations that were vault toilets of wood-frame construction, but other types were encountered. Driving time and accessibility varied greatly, as did intensity of use, number of facilities, and effort required for satisfactory cleanup. Oak Creek was a sensible choice, since it has been used during tests on the small Recreation Facilities Cleanup Vehicle and this allowed for a comparison of test results. North Fork/Trappers Lake provided for tests at elevations up to 9,800 ft. Georgetown Lake was a fortunate choice because of the unusually interested and cooperative personnel. This field unit provided more data than requested, as well as the most comprehensive report we have received on this or previous related projects.

The first day or two of the testing period at each of the four sites was used to demonstrate the slip-on unit to interested Forest Service personnel and to train the employees who were to operate the equipment. The necessary record keeping was also explained to those who were to use the equipment. The formal tests were designed to make a comparison between the cost of cleaning by the slip-on package and the cost of cleaning by normal, manual methods. Information on the adequacy of the design, size, the efficiency on the various pieces of equipment were also to be gathered.

The assigned operators were requested to maintain daily log sheets for each site, listing the number and type of comfort stations, fixtures, tables, and other cleaning tasks. Any other maintenance work done was to be included on the sheets, along with the time required to do the jobs and the hourly rate of the operator. Additionally, the daily costs of cleaning supplies, gasoline, oil, and mileage were to be itemized. Space was also provided for remarks and for listing any other equipment used. The operator had also been requested to maintain similar log sheets for a 1-month period during the summer season in order to obtain comparative data for slip-on equipment vs. manual cleaning methods.

At the end of the 1-month operational trial use period at each site, the operator and his supervisor were requested to fill out an overall appraisal form. This form asked many specific questions regarding performance of the equipment and its features. This form also provided space for remarks covering the operator's observations and suggestions for improvements.

COMMERCIALLY AVAILABLE SLIP-ON EQUIPMENT

Near the completion of the prototype testing period in 1971 SDEDC was contacted by Coxwells Inc. of Los Angeles, California. This is the firm that had originally supplied the spring-retractable reel for the combination hose/cable and later was awarded a contract to manufacture the first Recreation Facilities Cleanup Vehicles. They indicated that they also planned to develop and market a slip-on cleaning equipment package for pickup trucks. After an exchange of criteria and design ideas with SDEDC, they did develop and market such a unit. The Coxwells' unit is functionally identical to the SDEDC unit. However, it is physically different, and does have some additional features (fig. 2).

We decided to procure one of Coxwells Inc. first production models and test it informally in an attempt to compare its performance with our design. To this end, in the summer of 1972, both the Coxwells unit and the SDEDC final design unit were operated by personnel of the San Bernardino National Forest. The Big Bear and San Gorgonio Districts used the units for two weeks each. Daily log sheets were not kept, but both Districts were asked to make comparative appraisals of the two units.

TEST RESULTS

Prototype Design

During the 4 months of formal testing, about 1,000 comfort stations (1,800 fixtures) were cleaned with the slip-on package. There

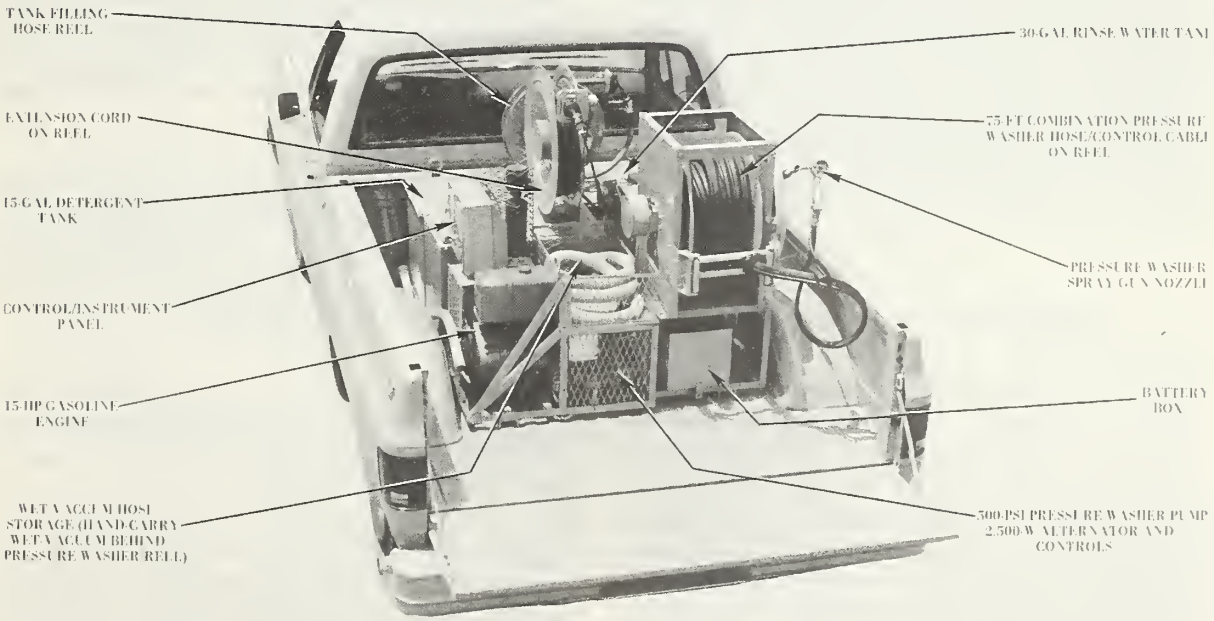

Figure 2. Commercially available slip-on cleaning equipment.

Table 1. Average time required to clean comfort stations.

	Total number of comfort stations cleaned	Total number of fixtures cleaned	Average time per comfort station (min)	Average time per fixture (min)
With cleaning equipment package	1,003	1,804	24.5	13.6
Without cleaning equipment package	552	880	39.5	23.4

were also 125 tables, 16 fireplaces and stoves, 8 garbage cans, and 8 vehicles cleaned, and the slip-on package was even called upon to attempt to douse a small fire. Only two of the test sites furnished data for their normal manual procedures, so there are data on manual cleaning for only about 500 comfort stations (900 fixtures), and none for other cleaning jobs.

Table 1 presents overall averages of the comfort station cleaning data. On the average, cleaning time was reduced by about 40 percent by using the slip-on cleaning equipment package. Other test data showed that it required about 7 minutes to clean a table with the slip-on equipment. This time cannot be compared with the cleaning time by normal methods, as no such data were furnished. There were insufficient data for other cleaning tasks to establish average values.

Summary of Overall Appraisals

The overall appraisal forms produced many useful comments. Some of the suggestions could not economically be incorporated in the final design, but a serious attempt was made to include suggestions frequently aired. There was a considerable quantity of comments and recommendations on the appraisals, as well as excellent memos from two of the test sites. These findings are summarized in the following paragraphs.

Formal Tests

The pressure washer was unanimously felt to be "satisfactory" to "very effective" in cleaning quality. Reliability of the controls was frequently only considered "fair" to "poor." The fan-tip spray-gun nozzle was stated to be the best nozzle, and one District felt that 25 ft more hose was needed.

The sizing of the tanks was rated as satisfactory by the majority, but one District felt that all 45 gal should be detergent solution with no rinse water supplied.

The backpack wet-vacuum cleaner was found to function well. However, it was described as being "very awkward," "heavy," and "too cumbersome" within the confines of a small comfort station.

The hand-carry wet-vacuum cleaner was found to be "good" at drying and picking up dirt, toilet paper, and debris. Two Districts felt that the wheels were not effective and that the floor tool was too long.

The extension cord reel broke during the tests and was replaced by one manufactured by a different company. The replacement reel appeared to be superior.

As for the effectiveness of the cleaning job done by the unit, the users cited "better job of cleaning," "increased ease of cleaning," and "does a far superior job in less time and is not as strenuous."

Most Districts felt that it made the job less distasteful. Most Districts also felt that the unit should be smaller, and half of them felt that there was no need for the tool and supply box. Some indicated a need for better access to the suction-line strainers, and half of the Districts felt there was a need for a holder (or holster) for the washer spray-gun nozzle.

Comparison Tests

Comments on the pressure washers of both the Coxwells and the SDEDC units were similar to those received during the formal tests, except that the reliability of controls was found to be "good." This higher rating was the result of changes that were made to the controls after the completion of the formal tests.

The tank sizes of the two designs were identical and were felt to be adequate. One of the Districts did not feel that there was any need for rinse water, but did feel that the small tank-filling hose reel was useful.

Neither District felt that the wet-vacuum cleaning was ideal and that there was any need for the special storage space for the wet-vacuum provided on the Coxwells unit. One of the Districts felt that the wheels were unsatisfactory.

The extension cord reel was found to be a good accessory, but at one District the support bracket on the reel broke.

Both Districts felt that the tool and supply cabinet (at that time only on the Coxwells' unit) should be deleted, along with the tank level gauges.

Both Districts felt the units are effective, but neither felt that it made the job less distasteful. They both experienced problems of bolts and nuts loosening because of engine vibration (particularly on the SDEDC unit). One District felt that the wet-vacuum cleaner hose storage rack on the Coxwells unit should be relocated away from the engine. This District also felt that the control panel on the Coxwells' unit should be relocated to the rear of the unit, and that the battery box needed a better latch. Both Districts felt that the lighter weight of the SDEDC unit was a significant advantage.

FINAL DESIGN

After the test data and field appraisals were reviewed, SDEDC began to refine the prototype design into a final design. Field suggestions regarding reducing the size of the package, combined with the poor acceptance of the tool and supply cabinet, resulted in elimination of the cabinet. This change makes the package about 30 percent smaller.

The high-pressure washer controls were simplified and their general reliability was improved. In conjunction with this, the arrangement of plumbing and controls was modified to provide better access to the strainers and solenoid valves.

The backpack wet-vacuum cleaner was eliminated in favor of the hand-carried wet-vacuum cleaner. The problem with the hand-carried wet-vacuum cleaner wheels traveling on rough gravel was investigated, but no economical solution was found. Attempts to operate this vacuum without its wheels were unsatisfactory. Without its wheels for a base, the vacuum is very unstable and tips over easily. When this happens, dirty water flows into the wet-vacuum cleaner's blower and motor, resulting in damage to the cleaner.

Lock-washers or self-locking screws were incorporated throughout. In addition, the engine mountings were changed to add rubber vibration isolators.

A holder for the high-pressure washer spray-gun nozzle was also incorporated into the final design. The final configuration of the SDEDC slip-on unit is shown in figure 3. It weighs about 1,150 lb when loaded with all liquids, fuel, etc. The Coxwells unit under the same conditions weighs about 1,300 lb.

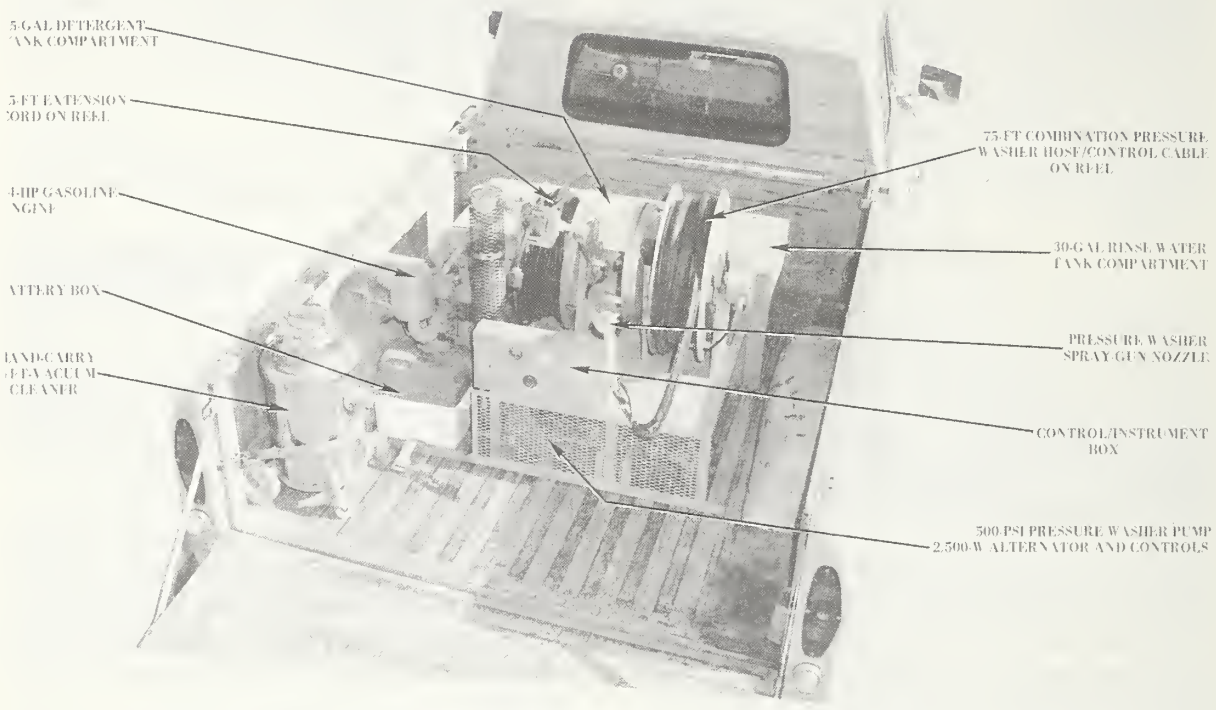

Figure 3. Final configuration of slip-on equipment for cleaning recreation facilities.

The manufacturers of the extension cord reel were contacted and agreed to strengthen their model.

Coxwells Inc. was also contacted, and the field's comments on their unit were provided to them. They indicated a desire to redesign their unit, and said that they would consider the suggestions.

CONCLUSIONS

1. The slip-on cleaning equipment package can substantially reduce the time spent in cleaning campground facilities. This is accomplished by providing mechanized cleaning equipment to remote areas, allowing pressure washing and rinsing of facilities and vacuum pickup of waste water, excess detergent solution, dirt, and debris. Manual cleaning can perhaps produce better results, but only if much more time is spent by very conscientious workers. Field personnel felt that the mobile cleaning equipment made the job more acceptable. Thus the slip-on equipment almost always improves the quality of the cleaning in addition to doing the job in less time.

2. The equipment shows its best potential for cleaning the interior of comfort stations. Other jobs it performs well are cleaning tables, louvers, vent screens, building exteriors, signs, and vehicles. With the proper detergents, it also has value in cleaning stoves, grills, garbage cans, and vehicle engines.

3. The Coxwells Inc. slip-on cleaning unit is functionally similar to the unit developed by the Forest Service. Both an interim performance and design specification (3, 4) have been issued to assist in procurement of these units. The design specification with its drawings can be used to contract for the Forest Service unit; the performance specification facilitates purchase of the Coxwells (or any equivalent) unit.

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